REMOTE SENSING ANALYSIS OF LAND COVER WITH SUGARCANE APPLIED TO THE ENVIRONMENTAL STUDIES IN NORTHWEST OF SÃO PAULO STATE, BRAZIL

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1. Abstract

Sugarcane is the basis of the Brazilian Alcohol and Sugar Industry. The technique of harvesting is increasing in Brazil and mapping and monitoring the areas in agricultural lands constitutes an enormous challenge for planning the soil management in the complex agricultural sugarcane production system. Using remote sensing technology and geographical information systems, the research work was conducted for evaluating the land cover with the leafy tops of the cane stalks that stay on the ground after harvesting for provisioning an environmental study in northwest of São Paulo State, Brazil. The land use and the predominant area of row sugarcane harvesting were evaluated in an area of 671089 hectares. Satellite images were gotten from the CBERS-2 Program. Four satellite images from CBERS-2 CCD camera, of the point 156/127, date 08/13/2004; 08/14/2005; 08/15/2006 and 08/16/2007 was used for processing and for image classification potential. The spectral bands used were RGB. Geographic Information System (GIS) was used to analyze the data. The raw harvesting land cover data was identified and differentiated from the spectral response patterns and a map of the area was developed using the supervised image classification. For analyzing the pixels was done a field observation and annotation in the training sites obtained with global positioning system and it was create a spectral signatures for the cutting stalks that stays at ground level after sugarcane harvesting. The image was classified considering each pixel comparing the similar signature made through statistical analyses. Testing the significance of spectral bands it is observed that has been an increasing in the size of raw harvesting area. As have been seen, from the total area of the image of 671089 hectares, occurred an increasing area between the years 2004 and 2006, with a minimum reducing in 2007. The area estimated in the last four years of land under harvest raw sugarcane cultivated is: 2004-39665 hectares (6%); 2005 – 44756 hectares (7%); 2006 – 51154 hectares (8%) and 2007 – 47460 hectares (7%), of the total area. Additional sources of clime showed that the small decreasing after 2006 was due to the precipitation that occurred before the time of satellite data, which delayed the raw harvesting. This work has shown that the spectral characteristics of sugarcane at raw harvesting are significantly similar.

2. Introduction

The agricultural activity is the great importance on Brazilian economy, and estimating production level is essential, mainly on precision farming. The change of the land use and vegetal covering is occurring in a fast way. Those changes in terrestrial ecosystems are strong associate to the processes of economic and social development, mainly in underdeveloped countries, where planning the soil management in the complex agricultural sugarcane production system does not meet the exploring in a sustainable way, mainly the resources of the land. With the easiness of accessing better information proceeding from remote sensing techniques, the use of new sensors, with better space, temporal and spectral resolutions have been very important for better knowledge of the ecological and antropic process that act in the terrestrial system.

Agricultural surveys with remote sensing technologies are necessary and objective, together with the knowledge of the spectro of the cultures, the data is better obtained and explored (Sanches, 2004).

In Brazil, the sugarcane production is the base of the Brazilian sugar and alcohol industry. This plant grows during 12 to 16 months before being harvested between April and November of each year. The culture system of raw sugarcane was developed with the purpose of eliminating the burning of the culture, the superficial soil mobilization and maintaining it covered with remaining plant parts. In this system, it searches reduction of the erosion and an increase of the organic substance, that provoke the superficial compacting of the soil and reduction of its total porosity, which will be able to restrict the development of the of the cultures (Blair, 2000; Vasconcelos, 2002).

When sugarcane is four meters or more of height and can be harvested by machines, the harvester removes the sugarcane, carrying through the leafy tops of the cane stalks that stay on the ground after harvesting, also removing an amount of pieces of the plant, triturating and launching to the land, forming a cover with vegetal residue (mulch). This technique of mechanized harvesting of sugarcane is increasing in the systems of

production in Brazil, mainly to finish a historical problem in the sugarcane sector that is the forest fire for manual harvesting, that provoke environmental damages as: the impoverishment of the ground, the deaths of wild animals and the greenhouse effect. Therefore, those agricultural areas constitute, for demarcating and monitoring an enormous challenge for a better management and planning the production system.

The remote sensing has great potential associated to geoinformation techniques for monitoring the agricultural activity and for supplying better statistical analysis on planted area and productivity (Terres et al., 1995; Ippoliti-Ramilo et al., 1999; Rizzi, 2004).

Using remote sensing technology and geographical information systems, the research work was conducted for evaluating the land cover with the leafy tops of the cane stalks that stay on the ground after harvesting for provisioning an environmental study in northeast of São Paulo State, Brazil.

3. Methods

The study area is around 671089 hectares, between the latitudes 22º 43' 38"and 22º 57' 39" S and longitudes 48º 17' 34"and 48º 26' 28" W, located in the northwest region of the state of São Paulo, with tropical climate, with annual rainfall of 1200 mm and temperature of 22ºC during summer and 18 ºC during winter, and altitude that varies from 578 to 722 m.

The land use is mainly for sugarcane, with mechanized agricultural harvesting. Images of satellite from CBERS-2 Program had been obtained. The Program was originated from a technician-scientific segment between Brazil and China in the space, to be used in important areas as: deforestation, monitoring of hydra resources, land occupation, and others applications.

The CBERS-2 satellite has an orbit heliosynchrony, an altitude of 778 km, making 14 revolutions per day. In this orbit, the satellite always crosses the Equator in the same local hour, 10:30am, thus allows the same condition of solar illumination for comparing images taken in different days. An important characteristic of the satellite CBERS-2 is the diversity of cameras with different space resolutions and frequencies of collection of data. They are the unique systems that use cameras that the characteristics give a great variety for analyzing typical secular and space scales of our ecosystem.

The first step of the work was to elaborate a cartographic base of the study area, using the Geographic System Information - IDRISI-2.0. This applicatory of geoprocessing, by means of its modules, allows the accomplishment of mechanically multiple tasks, necessary to obtain a visual analysis of the areas of harvested sugarcane. The identification, the mapping and the quantification of the interest areas had been made by supervised classification, after the elaboration of a composition false-color (Figure 1), from data collected from the sensor "CDD" of the Satellite CBERS-2, in bands 2, 3 and 4, with colors green, red and next infra-red ray, respectively.

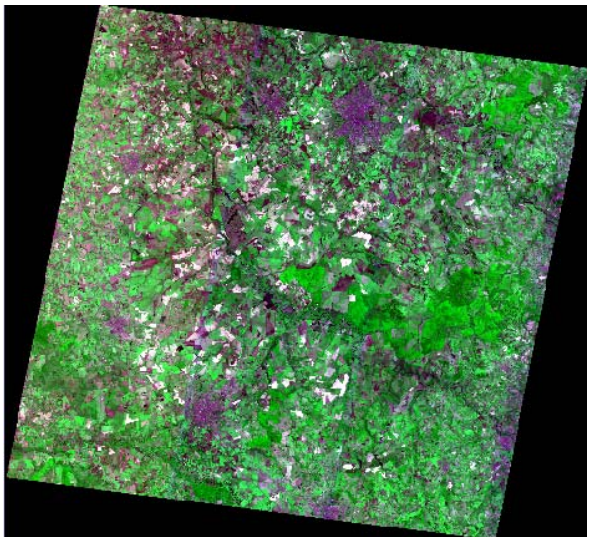

Figure 1 False color compositioning (3R4G2B)

After georreferencing, has been made the mark of the training areas on the color image, using for this the cursor in some places, looking for enclosing the maximum of possible areas. After that, the spectral signature was created mechanically harvested sugarcane for the module "*Makesig"* and later the supervised classification by parallelepiped, using the module "*Piped*". In the supervised classification, the land covered with the leafy tops of the cane stalks that stay on the ground after harvesting by agricultural machine was identified and

differentiated. The training areas had been delimited by polygons on the image. An archive of signatures for each category was recommended for each category of land use, associated with its respective identification in the box-text created. The image was classified based in those data, and some samples had been confirmed in field work, using Garmin GPS eTrex Vista. In the sequence, the image was classified considering each pixel comparing the similar signature made through statistical analyses. For testing the significance of spectral area of sugarcane mechanically harvested for the years of study 2004, 2005, 2006, 2007, was used the command "*area"* that is in the module "*Database Query*".

The satellite data were collected on 08/13/2004; 08/14/2005; 08/15/2006 and 08/16/2007 corresponding to orbit 156, point 127. In this false color composition, the areas of interest, harvested raw sugarcane, reveals in whitely tones. However, before the generation of the false color for each year, the georreferencing of bands 2, 3 and 4 was made separately, using the module "*Reformat/ Resample*" of the SIG-IDRISI-2.0, being the points of control for georreferencing gotten at the topographical map of Jaboticabal - SP, in scale of 1:50000 and confirmed in the field with the Garmin navigation GPS/eTrex (Figure 2).

Figura 2 View of the land cover with the leafy tops of the cane stalks that stay on the ground after harvesting of of the control points

For the geometric correction process of the digital images, it has been delimited some control points distributed by all the surface of the image, preferring control points at the end corner of each image. Those points must be perfectly visible in the image, as in topographical maps to allow a better georreferencing.

4. Results

The use of the images data of the satellite CBERS-2 was a goal that turned possible the analysis of the covering of the land use with mechanized harvest of the sugarcane, identifying and differentiating the spectral standards, due to its mainly better space and spectral resolution.

The results had shown that the bands that make possible greater differentiation of the targets had been bands 2, 3 and 4, and the spectral characteristics of sugarcane for mechanized harvest are significantly similar, indicating that those characteristics can be useful to maximize the discrimination of areas of interest in the evaluation of the land use, being able to foresee the estimate of the areas with mechanized harvest passing the years.

After the analysis of the spectral bands was observed an increase in the size of the area planted with sugarcane in a mechanized harvesting. It has been verified an increasing area between 2004 to 2006 and a minimum reduction in 2007 (Table 1 and Figure 3).

Table 1 Area of row sugarcane harvesting

Year	Area of row sugar hectares	Area of harvesting %
2004	39665	6%
2005	44756	7%
2006	51154	8%
2007	47460	7%

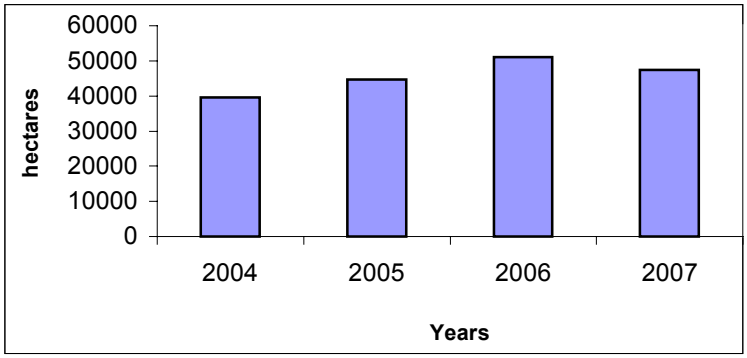

Figura 3 Area of row sugar harvested

Sources of climate had shown that this small reduction of harvesting area from 2006 to 2007 was due to precipitation in April (54 mm), May (106 mm) and July (88 mm), 2007 year, delaying the period of mechanized harvest. It is important to stop cutting of the sugarcane due to precipitation excess, with rain above of 40 to 50 mm, the process are suspended. According to Aguiar & Silva (2005), the rainfall occurrence is the main impediment for the normal course for cutting sugarcane on the harvesting period, therefore it directly affects the transit of the involved machine, in same way, for cutting sugarcane, for mechanized harvesting, and for transporting the sugarcane to the unit of production.

The mechanization of the sugarcane harvest process not only increases the operational income of the procedure, as also, reduces its ambient impact, for controlling the burning of residues. The results contribute for controlling and consequence economy of the applied products, reducing the risks of ambient pollution, diminishing the production cost, and consolidating the leadership of the country in this sector. The practice of harvesting, without using fire, is spreading for several other regions of the country.

Brazil, being the world-wide leader of the production of sugarcane, with 30% of the free market of sugar, is the first country of Latin America, where the politic of abolition of forest fires in the sugarcane plantations is becoming each time more important, as an example for sustainable agriculture and low ambient impact. This work has shown that the spectral characteristics of sugarcane at raw harvesting are significantly similar. The digital processing analysis of images with the Geographic Information System (GIS) was possible to especially monitoring the spacial and temporal evolution of the mechanized harvesting for 4 years. Before the found results, the considered system can be used as support for better planning of the land use.

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